DOCUMENT RESUME

ED 158 979 SE 024 669

TITLE Agricultural Plant Pest Control. Manual 93.
INSTITUTION Missouri Univ., Columbia. Agricultural Experiment Station.; Missouri Univ., Columbia. Extension Div.
PUB DATE [77]
NOTE 57p.; For related documents, see SE 024 665-671 and SE 024 748-751; Colored photographs may not reproduce well

EDRS PRICE MF-$0.83 HC-$3.50 Plus Postage.
DESCRIPTORS Agricultural Production; *Certification; Disease Control; Entomology; *Instructional Materials; *Pesticides; *Plant Science; *Post Secondary Education; Safety; *Units of Study; Weeds
IDENTIFIERS *Missouri

ABSTRACT

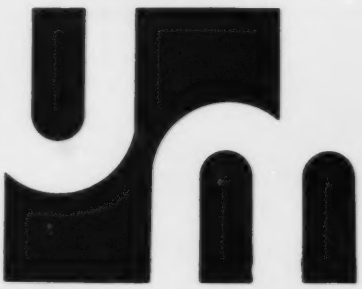
This training manual provides information needed to meet the minimum EPA standards for certification as a commercial applicator of pesticides for the agricultural plant pest control category. The text discusses the insect pests including caterpillars, beetles, and soil inhabiting insects; diseases and nematodes; and weeds. Consideration is given to pesticide formulation and application as it relates to effectiveness and environmental contamination. (CS)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

U S DEPARTMENT OF HEALTH,
EDUCATION & WELFARE
NATIONAL INSTITUTE OF
EDUCATION

THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL NATIONAL INSTITUTE OF EDUCATION POSITION OR POLICY

- ED158979



AGRICULTURAL PLANT PEST CONTROL

manual 93

This manual was developed in cooperation with The Missouri Department of Agriculture and the Coop Extension Service, University of Missouri.

Assembled by Members of Extension Pesticide Training Team

SE 024 669

INTRODUCTION

This training manual is intended to provide information needed to meet the minimum standards of the Environmental Protection Agency. It is also intended to prepare you to take an examination for pesticide applicator certification given by the Missouri Department of Agriculture based on this manual. This training will not provide all the information needed for effective Agricultural Plant Pest Control. Additional information in the form of publications and short courses can be obtained from the University Extension Centers.

This material was adapted to Missouri conditions from a pest control manual developed by the University of Georgia Cooperative Extension Service.

TABLE OF CONTENTS

INTRODUCTION
CROPS 1
INSECT PESTS 2
Caterpillars
Foliage and Fruit Feeders 3
Boring and Tunneling 3
Beetles and Bettle Larvae 4
Soil Inhabiting Insects 5
Sucking Insects 5
Colored Insect Picture Sheets
No. 1 - Principal Stored Grain Insects
No. 4 - Corn Insects - Above Ground
No. 5 - Corn Insects - Below Ground
No. 6 - Common Soybean Insects
No. 7 - Common Small Grain Insects
No. 8 - Common Forage Legume Insects
No. 9 - Common Vegetable Insects
No. 10 - Common Fruit Insects
DISEASES AND NEMATODES 7
Leaf Diseases 9
Leaf Spots 9
Leaf Blights 10
Rusts 11
Powdery Mildew 11
Downy Mildew 12
Wilts, Root and Crown Rots 13
Wilts 13
Crown and Stalk Rots 15
Root Rots 16
Stem Cankers 17
Fruit Rots 17
Seed and Seedling Diseases 19

Virus Diseases 19
Nematode Diseases 21
WEEDS 24
Perennial and Biennial Weeds 25
Annual Grasses 26
Small-seeded Broadleaf Weeds 26
Large-weeded Broadleaf Weeds 27
PESTICIDES 27
Formulations and Sources of Information 27
Application 28
Insect Control Chemicals 28
Disease Control Chemicals 29
Fungicides 29
Bactericides 30
Nematicides 31
Weed Control Chemicals 31
Selective Herbicides 31
Non-selective Herbicides 31
Contact Herbicides 32
Translocated Herbicides 32
SPECIAL PROBLEMS
Pre-harvest and Re-entry Intervals 33
Phytotoxicity 33
Residues 34
Environmental Contamination 34
Non-target Injury 35
Contamination of Soil and Water 35
ADDITIONAL REFERENCES 37

CROPS

Missouri produces a wide variety of agricultural crops. Major crops are grown on large acreages of varying soil types and diversified terrain. Specialty crops are usually grown on small acreages and often on the specific soil type best adapted for each crop.

Modern production techniques require the use of quantities of pesticides. These pesticides often enable the producer to maintain production of quality products, providing the consumer with food and fiber at low cost. However, these pesticides must be used in a manner that will benefit society as a whole with the fewest possible undesirable side effects.

Crops may be included under such general headings as: field crops, forage crops, vegetables, fruits and nuts, nursery crops, greenhouse crops, turf (sod), and Christmas trees. Growers may need to apply pesticides to all these crops to reach maximum production of a quality that consumers will buy.

When planning crop production, consider the pesticides that will be used during planting, growing, harvest and storage. Then consider the method(s) to be used in applying these pesticides. Will either the method of application or the chosen pesticide present an undue risk of contaminating non-target areas? Try to minimize such problems. Eliminate them if possible.

Care must be exercised in the handling, mixing, and application of pesticides to any crop. Formulation, concentration, and application method vary, and all are factors affecting hazard to the applicator and the environment.

INSECT PESTS

Insects are probably the most abundant form of animal life on earth. More different species (kinds) of insects are presently known than all other animals combined. Approximately 1,000,000 different species are now known to man. Several thousand different species are known to occur in Missouri.

Fortunately, only a very small percentage of Missouri's insects are considered to be economically damaging to agricultural plants. Each of our crops has a few insects which are termed major pests and several which may occasionally be minor pests.

More useful or beneficial species of insects exist than those that are destructive or damaging. Insects are determined to be useful or beneficial when they perform any of the following services: act as predators or parasites of other insects; produce a usable product such as dyes, shellac, silk and honey; serve as plant pollinators; provide food for other land and water animals; and serve as scavengers by eating decaying organic matter.

Insects are determined to be pests when they cause losses that exceed the cost of control efforts. Pest insects are our greatest rival for available food.

When damaging infestations occur, or threaten to occur, they must be controlled if losses are to be prevented. The most reliable means of controlling damaging populations of crop insect pests is through the proper use of insecticides. Other non-chemical means of reducing crop insect pests include crop rotation, cultural practices, use of resistant varieties, observing planting dates, and destruction of plant residues. Use any of these non-chemical means of insect control that fit into your crop production practices to reduce

dependence upon insecticides.

The first and most important step in dealing with an insect problem is identifying the pest or pests involved. Commercial pesticide applicators, pesticide dealers, and University Extension entomology, agronomy and horticulture specialists can aid in making or obtaining a correct identification. Once the insect has been identified, information on its life cycle and habits can be determined. From this information, a proper method of control can be selected.

Major and minor pests of several of our crops are illustrated and briefly discussed on the "Colored Insect Picture Sheets" following this section.

Crop insect pests damage plants either by their chewing type of mouthparts or by sucking plant sap with their piercing-sucking type of mouthparts. Some few crop insect pests may feed on only one variety or kind of plant. Other pests may feed upon a group of related and similar plant species, while other pests may feed upon a wide variety of plants. This last group is known as "general feeders".

Some of these insect pests may feed only upon the foliage of crops. Other pests may feed only on the fruit, and still others may feed on both foliage and fruit. Some examples include several species of grasshoppers, "true" armyworms, fall armyworms, corn earworm, variegated cutworm and tomato hornworm.

The larval stage of some insect pests cause injury by boring or tunneling within the plant or its fruit. Most of our crops are attacked by one or more species of these pests. Examples include European corn borer, Southwestern corn borer, peachtree borer, most round and flat-headed borers, and several species

of leaf miners.

The length of time that boring or tunneling pests are exposed after eggs hatch and before the small larvae enter the plant is relatively short. Insecticide application must be timed during the period that the pest is outside the plant and before it begins to tunnel. Some species may be controlled by systemic insecticides that are absorbed by the plant being attacked.

Many different species of beetles and their larvae are important pests of crops. In most instances, both adult and larval stages damage plants. Adults usually feed on some exterior part of the plant, such as leaves, stem, flower or fruit. Larvae usually feed on or within a plant part in the soil or within the stem or fruit. Examples include corn rootworms, several species of flea beetles, bean leaf beetle, striped cucumber beetle, alfalfa weevil, plum curculio and pecan weevil.

Control of this group of beetles will depend upon the adult feeding and egg laying habits. Several of the weevils lay their eggs within plant tissue and their larvae develop internally. Therefore, control largely depends upon one or more well-timed insecticide applications intended to destroy the adults before egg laying occurs.

Leaf feeding beetles lay their eggs either on the plants or in the soil and their larvae feed on or in plant tissue. Therefore, control with insecticides may be directed against the adults before egg laying. However, control with insecticides is usually directed against the larval stage either as a foliar application or as a soil incorporated application.

Below ground feeding insects are important pests of Missouri crops. Because of their soil habitat, these pests are difficult to detect, and population evaluation is even harder. They may feed upon planted seed or on underground parts of plants.

Damaged plants are often stunted to the point they never fully recover, or plants are killed thereby reducing or destroying the stand. Examples include seed corn beetles, seed corn maggots, subterranean cutworms such as the black cutworm, dingy cutworm and other species, wireworms, corn rootworms and white grubs.

The length of life cycles of these below ground feeding pests vary tremendously. Some may require three or more years while others require about one month to complete a life cycle.

Methods of control for this group of pests also varies and may be difficult to obtain. Crop rotation is an effective control for northern and western corn rootworms. Plant residue plowdown seems to reduce some species of cutworms. Treating seed with an approved seed treatment insecticide protects the weed from seed-damaging pests until germination. The most widely used control consists of a preplant, soil incorporated insecticide application. Some of these pests may also be controlled by insecticides applied to the soil surface near the base of the young plants. Any insecticide applied to the soil must be used in a manner that is effective against the pest, yet does not create a hazard to wildlife nor contaminate water.

Sucking insect pests consist of a large number of different species and families of insects. They insert their piercing-sucking mouthparts into plant tissue and suck the sap for food. Some species inject

saliva in the feeding process which causes a deterioration or necrosis of the tissue fed upon. The feeding damage of other species causes a malformation of plant parts fed upon or cause the fruiting buds or newly set fruit to blast or drop from the plants. Examples of sucking insects include aphids (plant lice), leafhoppers, thrips, whiteflies, plant bugs, stinkbugs, scale insects and spider mites.

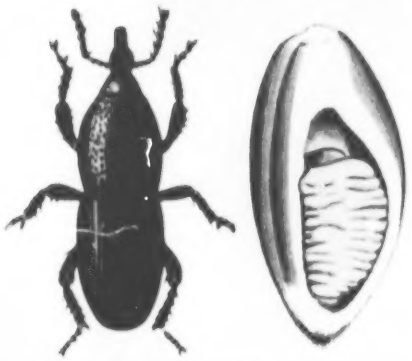
Sucking insect pests can be controlled by foliar applied insecticides. Since some of these pests occur primarily on underside of leaves, thorough coverage is essential. Some of these pests may also be controlled by planting time or by foliar application of systemic insecticides.

* *

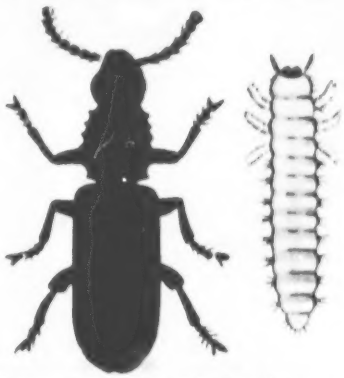
Please refer to those "Colored Insect Picture Sheets" which follow and that apply to your crop production. A brief discussion of habits, damage and life history is given for each of the pest insects illustrated. Use this information for your specific insect pest problems.

PRINCIPAL STORED GRAIN INSECTS

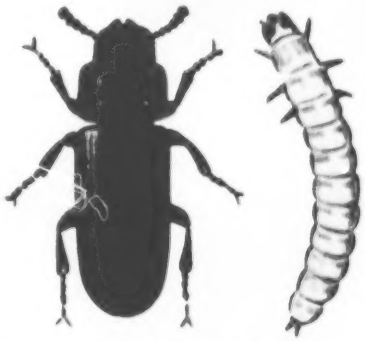
For safe and effective use of insecticides, always identify the problem correctly.



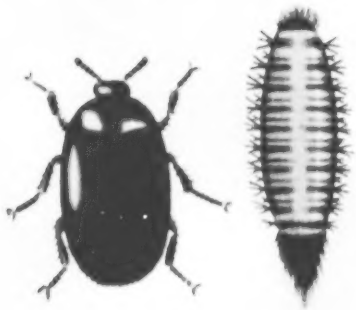
1. Granary weevil



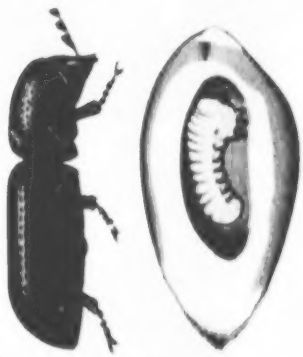
2. Saw-toothed grain beetle



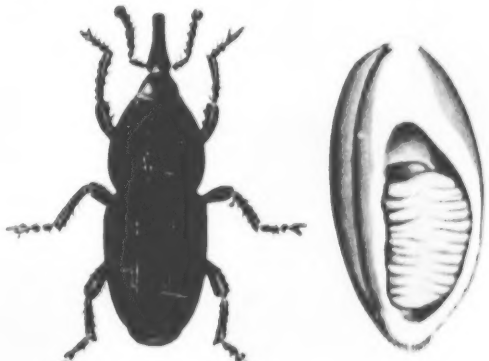
3. Red flour beetle



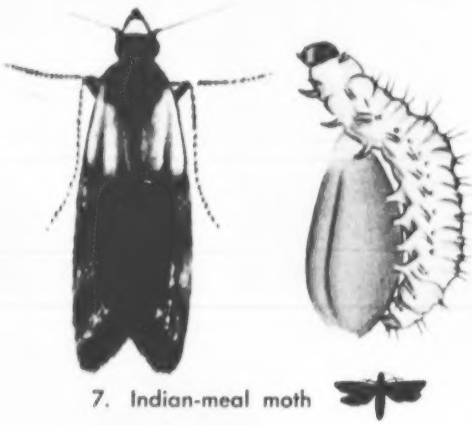
4. Larger cabinet beetle



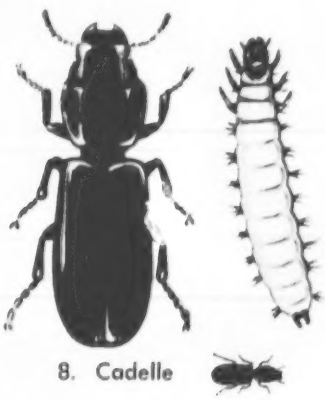
5. Lesser grain borer



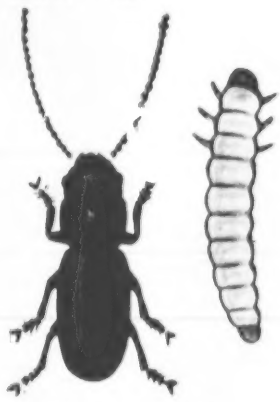
6. Rice weevil



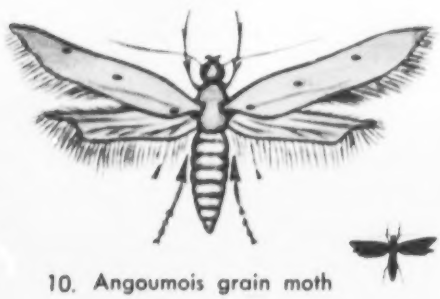
7. Indian-meal moth



8. Cadelle



9. Flat grain beetle



10. Angoumois grain moth

Some of these stored grain insects are also KITCHEN PESTS.

The saw-toothed grain beetle, red flour beetle, larger cabinet beetle, and Indian-meal moth develop in flour, cake mixes, corn meal, breakfast foods and similar products. The Angoumois grain moth infests popcorn.

Prepared by Extension Entomologists of the North Central States in cooperation with the Federal Extension Service, U. S. Department of Agriculture

6b

Principal Stored Grain Insects of Missouri

This is the first in a series of picture sheets prepared by Extension entomologists of the North Central states in cooperation with the Federal Extension Service, U. S. Department of Agriculture.

The principal species of stored grain insects found in Missouri are pictured showing both the adult and larval forms. The small, black drawings indicate the actual size of the insects.

DESCRIPTION

1. **Granary weevils** cannot fly. Eggs are placed inside whole kernels. Damage is caused by the larvae feeding in whole grain and the adults feeding in and on whole or broken grain.
2. **Saw-toothed grain beetles** seldom fly but both the larvae and adults feed on cracked or broken grain, flour, meal, breakfast food, stock feed, candy, and dried fruit. The thorax, the body region behind the head, has saw-toothed points on both sides.
3. Larvae and adults of the **red flour beetle** and a closely related species, the **confused flour beetle,** feed on flour, grain dust, and broken grains.
4. **Larger cabinet beetles** and several closely related species are general feeders on grain and grain products. They will also feed on material of animal origin, such as hides.
5. The eggs of the **lesser grain borer** are placed on kernels and the larvae bore into the kernels. The adults can fly and also feed on grain.
6. **Rice weevil** adults can fly. Eggs are laid inside the kernel. The larvae feed in whole grain while the adults will feed both in and on grain.
7. **Indian-meal moth** larvae spin webs on the surface of grain and feed on kernels enclosed within the webbing. The larvae will also spin webs on sacked grain in storage areas.
8. **Cadelle** larvae and adults feed on whole grain. The larvae bore holes in the wood within bins where they hibernate. This is one of the largest stored grain insects.
9. **Flat grain beetles** are one of the smallest common stored grain insects. It is usually found associated with out-of-condition or insect damaged grain.
10. **Angoumois grain moth** eggs are laid on the outside of the grain. The larvae bore into the grain and feed within the kernel. Adults may fly from granaries and infest corn in the field.

CONTROLLING STORED GRAIN INSECTS

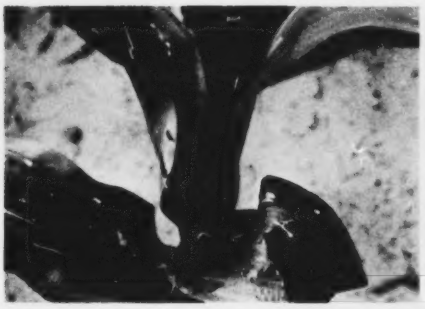
For control recommendations in farm bins see UMC Guide 7100, "Insects in Farm Stored Grain—Their Prevention and Control." For control in kitchens see UMC Guides 7374, "Angoumois Grain Moth and Indian Meal Moth;" and 7376, "Saw-toothed Grain Beetle, Confused Flour Beetle, and Red Flour Beetle." These are available at your county University Extension Center.

Issued in furtherance of cooperative extension work, acts of May 8 and June 30, 1914, in cooperation with the United States Department of Agriculture. C. B. Ratchford, Vice-President for Extension, Cooperative Extension Service, University of Missouri, Columbia, Mo. 65201.

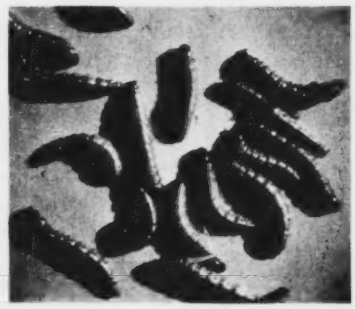
6c

CORN INSECTS—ABOVE GROUND

For safe and effective use of insecticides, always identify the problem correctly.

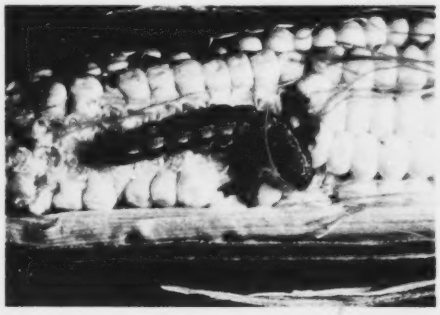


1. European corn borer (early leaf feeding and mature borers)



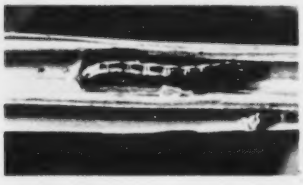
8. Grasshopper

2. Southwestern corn borer

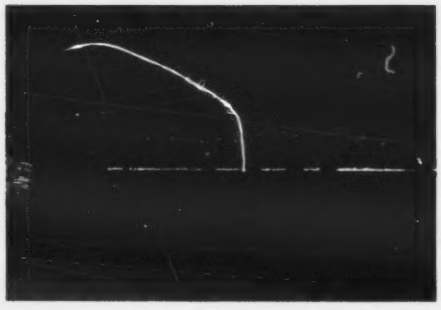


5. Corn earworm

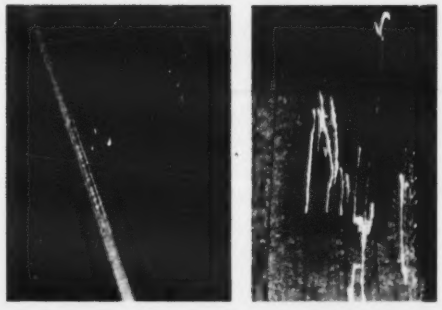
9. Corn leaf aphid



3. Common stalk borer



6. Armyworm



10. Corn flea beetle and damage

4. Chinch bug

7. Corn rootworm beetles (left to right: Northern, Western and Southern) These beetles clip silks causing poor pollination shown at far right.

Prepared by Extension Entomologists of the North Central States in cooperation with the Federal Extension Service, U. S. Department of Agriculture

6d

Missouri Corn Insects--Above Ground

George W. Thomas, Department of Entomology, College of Agriculture

1. European corn borer. Corn is its primary host, although it may attack many other crops and weeds. The full grown larvae overwinter in stalks and stems, and pupate in spring. Moths emerge in May and early June. The moths lay silvery white, fish-scale-like packets of eggs on the underside of corn leaves. Small larvae feed briefly on leaves, then move down into the whorl, and later bore into the stalk. These larvae pupate in June and July and a second generation occurs in late July and August. A third generation also occurs in southeastern counties. Later generations often cause stalk breakage and ear droppage.

2. Southwestern corn borer. This pest in southern Missouri overwinters as a full grown larva in the tip of the underground portion of the stalk. The borers pupate in May; adult moths emerge in June and lay eggs singly or in small packets on leaves. The white and black larvae bore into the stalk, feed, pupate, and produce a second generation of larvae in July and August. When full grown, a larva will tunnel down the stalk below ground, then move back up and girdle the stalk just above ground. Girdled plants frequently break off and fall to the ground.

3. Stalk borer. These larvae tunnel in the stems of numerous grasses, weeds, vegetables, flowers, and crops including corn. Damage to crops is more common in the marginal rows. The overwintering eggs hatch in late spring and the brown and white striped larvae with a purplish band behind the legs bore into the stems of grasses and weeds. They move to corn in June and tunnel from the whorl into the stalk. Larval growth is completed in July; the larvae pupate in the soil and the moths emerge during early fall and lay eggs.

4. Chinch bugs. Adult chinch bugs overwinter in bunch grasses. The adults fly to small grains in early spring to lay eggs, and the young are approaching maturity by the time of grain ripening. These *nymphs* crawl to nearby corn or sorghums where they suck sap from around the lower portion of stalks while completing their growth and becoming winged adults. A second generation is produced on corn and sorghums and the adults fly to the hibernation grasses in the fall. Heavily infested plants are stunted and wilted; their leaves may be red-streaked and plants may die.

5. Corn earworm. Overwinters in southern portion of state as pupae which emerge as moths in May. Moths may also migrate into state earlier. First generation larvae feed in the whorls of corn just before tassels are visible; the second generation feeds in the silks and ear tips just following pollination; and the third generation feeds in the ears of late planted corn and on the maturing grain. Larval colors vary from green, yellow, pink to brownish-black. The larvae attack several other field crops and garden plants.

6. Armyworm. Although some partially grown armyworm larvae will overwinter in Missouri, most of our troubles are believed to come from migrating moths. There are three generations annually, but the first causes most of the damage. The first generation is confined to grasses and small grains, but should a field be stripped before larvae mature, they will move into corn or other crops. The larvae will eat the leaves and down into the stalk. The *fall armyworm* is more of a problem on late planted corn than is the armyworm.

7. Corn rootworm beetles. These beetles are present from mid-July through September. The western and southern species may skeletonize small areas on the more tender leaves. All species feed upon silks and pollen from corn, other grain crops, legumes, and weeds. The beetles may keep the silks chewed back to the ear tip during the period of pollination, resulting in poor grain set. The number of beetles on corn during the egg laying period from August into October may serve as an indicator of rootworm problems the following growing season.

8. Grasshoppers. The nymphs and adults of several species of grasshoppers feed upon foliage, silks, and ear tips of corn from June through September. Damage is usually more severe during drouth years and is most noticeable along field margins bordering grass and wasteland areas.

9. Corn leaf aphid. Winged females migrate from small grains to corn during spring. Numerous generations are produced on corn and sorghums during the summer. The small, greenish-blue aphids may occur in countless numbers down in the whorl, on upper leaves, and on tassels. They are a vector of maize dwarf mosaic virus disease of corn. Heavy numbers occurring in whorls prior to tassel emergence can result in the plants' not producing shoots.

10. Corn flea beetle. The tiny, shiny black, jumping beetles move from grassland hibernation areas to seedling corn in early spring. They feed by stripping the upper surface from the leaf tips. Damage is more severe during wet, cold springs. Heavily damaged plants may die from a combination of flea beetles, root diseases, and cold weather. The beetles are a vector of Stewart's disease or bacterial wilt of corn. A second generation, of little or no importance, occurs during July and August.

Issued in furtherance of cooperative extension work, acts of May 8 and June 30, 1914, in cooperation with the United States Department of Agriculture. Carl N. Scheneman, Vice President for Extension, Cooperative Extension Service, University of Missouri, Columbia, Mo. 65201. The University of Missouri is an equal employment and educational opportunity institution.

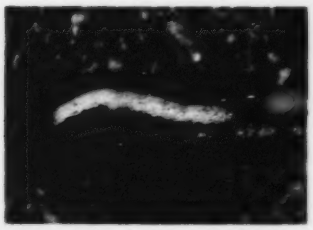
6e

Picture Sheet No. 5

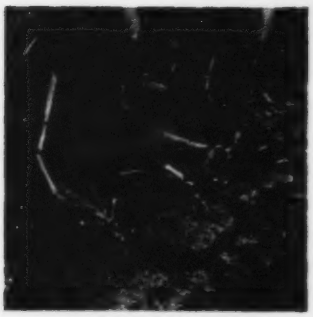
CORN INSECTS—BELOW GROUND

For safe and effective use of insecticides, always identify the problem correctly.

1. Corn rootworm adults (top-bottom: Northern, Western and Southern)



2. Corn rootworm larva

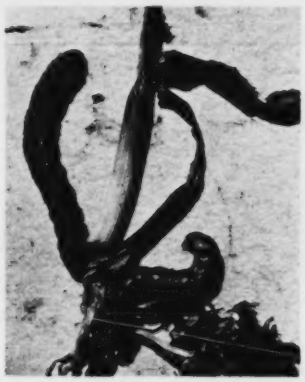


3. "Goose-neck" symptoms of corn rootworm infestation

4. Corn rootworm damage

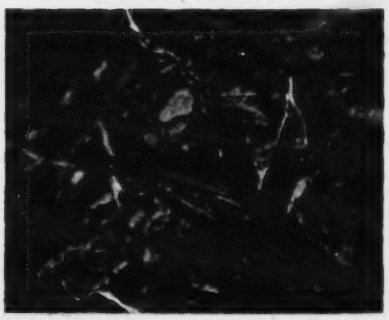
5. Wireworm

6. White grub

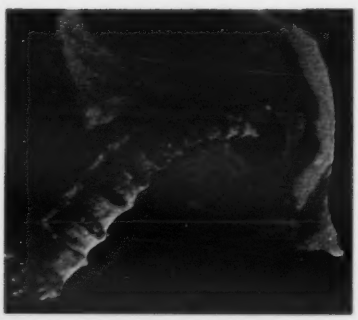


7. Black cutworm

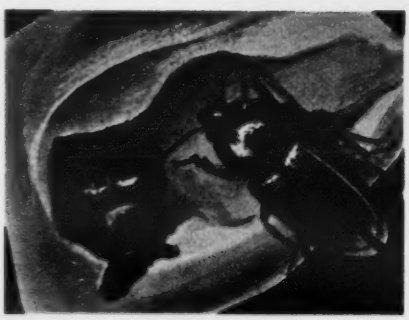
8. Corn root aphid



9. Grape colaspis and damage



10. Seed corn maggot



11. Seed corn beetle

12. Billbug (feeds on seedling corn plants below ground; holes in lower leaves of larger corn are evidence of this earlier feeding)

16

Prepared by Extension Entomologists of the North Central States in cooperation with the Federal Extension Service, U. S. Department of Agriculture

6f

Missouri Corn Insects--Below Ground

George W. Thomas, Department of Entomology, University of Missouri

1. Corn rootworm adults. Adult beetles may keep silks eaten off during period of pollination, resulting in poor grain set. The northern and western species have one generation annually and overwinter in the egg stage. These eggs are laid from August into October in the soil of corn fields primarily. The southern species overwinters as adults, and possibly as eggs. The southern species has two or three generations annually, and they will feed on and lay eggs in a wider variety of crops than the other species.

2. Corn rootworm larva. The eggs of the northern and western species hatch in late May and early June. The rootworm larvae feed upon and tunnel into the primary roots and later into the brace roots. The slender, creamy white larva, with a reddish-brown head and a dark brown spot on the tip of the abdomen, are about ⅜ inch in length when grown. The southern rootworm larvae are similarly shaped but are slightly larger and more yellowish in color.

3. "Goose-neck" symptoms. Corn that has had the roots largely destroyed by rootworm larvae often falls or is blown over during a rain and wind storm. If moisture is plentiful, these plants will attempt to right themselves, resulting in a lower stalk curvature often called "goose-necking."

4. Corn rootworm damage. Heavy rootworm infestations usually completely destroy the more tender roots, especially the last two sets of primary roots and the first set of brace roots. The tips of roots may be eaten off, tunneled into, or completely destroyed, resulting in a browning and rotting of the injured areas.

5. Wireworm. The hard, slick, orange colored larvae are from ½ to 1½ inches in length. They feed on the seed, bore into the underground portion of the stalk of seedling and small corn, and eat the more tender roots. From two to three years are required to complete a generation, but generations overlap so that all stages are present every year. Corn following grasses or sod is most subject to attack.

6. White grub. The larvae or grubs of the large, brown May or June beetles damage corn by eating off the primary roots. Injured corn shows stunting and patchy growth, is off color, and often dies. Three years are required to complete a generation, but generations overlap so that all stages are present each year. Corn following sod is most subject to attack.

7. Black cutworm. These and some other species of cutworm larvae may cut off seedling and small corn at or just above the ground during wet weather. In drier soils, the feeding is largely underground where the cutworms chew into the stalk, causing death of the above-ground portion. Damage is usually greatest in wet, heavy river bottom soils. Cutworms overwinter as partially grown larvae. Migrating moths lay eggs during the early spring. A second generation may occur in June and July following excessive rainfall and flooding.

8. Corn root aphid. These aphids overwinter as eggs in the nests of the corn field ant. In the spring, the ants carry the young aphids to the roots of small corn. The small, bluish-green aphids suck sap from roots. During dry weather, infested plants may become stunted and have reddish-yellow tinting on lower leaves.

9. Grape colaspis and damage. Corn following lespedeza or clover may show stunting, wilting, discoloration of upper leaves; or it may be killed by very small, fat, curved, white grubs which have eaten the primary roots. The small, elliptical, tannish-colored beetles feed on pollen, silks, and foliage of corn and soybeans during July.

10. Seed corn maggot. During cool, wet springs, and especially in soils with a high organic matter content, the germination of corn and soybean seed is often reduced by small, dirty grayish-white maggots which tunnel into and feed within the seed. The adult flies are about one-half the size of house flies and are often attacked by a fungus during warm, humid weather. Dead flies may be seen attached to vegetation. There are several generations each year.

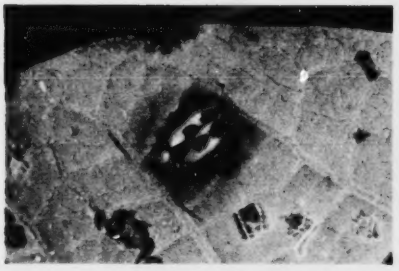
11. Seed corn beetle. During cold weather that slows germination, corn seed may be chewed into by a ground beetle about ⅜ inch in length with brownish-black wing covers margined with dull yellow. Large numbers of beetles are often seen at lights and both the larvae and adults are believed to be mostly predaceous.

12. Billbug. Several species of dirty, grayish-black weevils or snout beetles, about ⅜ inch in length, overwinter and attack seedling and small corn in the spring. The billbug eats one or more small holes in the stalk at or near ground level. When the damaged leaves unfold, they exhibit a series of concentric holes across the blades. The fat, curved, legless, white grubs may also tunnel in the pith of the lower stalk. The problem is more severe on corn planted in bottom fields where reeds and sedges have been growing or in old timothy meadows.

Issued in furtherance of cooperative extension work, acts of May 8 and June 30, 1914, in cooperation with the United States Department of Agriculture. Carl N. Scheneman, Vice President for Extension, Cooperative Extension Service, University of Missouri, Columbia, Mo. 65201. The University of Missouri is an equal employment and educational opportunity institution.

COMMON SOYBEAN INSECTS

For safe and effective use of insecticides, always identify the problem correctly.

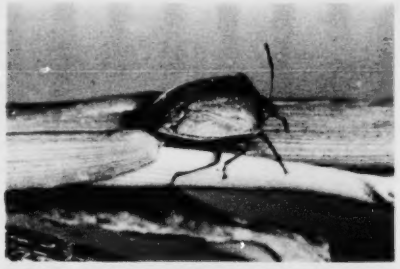


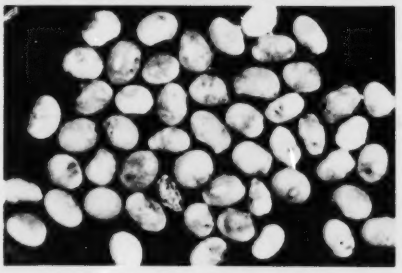
1. Bean leaf beetle

2. Mexican bean beetle and larva

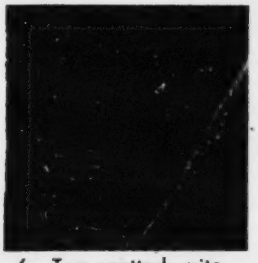
3. Japanese beetle

4. Striped blister beetle





5. Green stink bug and damaged seeds

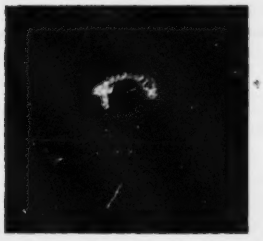


6. Two-spotted mite (not an insect)

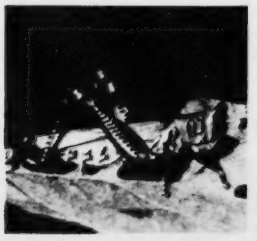
7. Thrips (greatly enlarged)

8. Grape colaspis larva

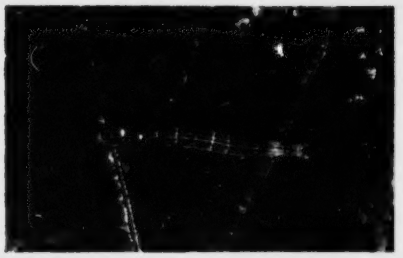
9. Seed maggot



10. White grub



11. Grasshopper



12. Green clover worm

13. Cabbage looper

14. Garden webworm

15. Corn earworm

Prepared by Extension Entomologists of the North Central States in cooperation with the Federal Extension Service, U.S. Department of Agriculture

6h

Common Soybean Insects of Missouri

George W. Thomas, Department of Entomology, College of Agriculture

1. Bean leaf beetle adults overwinter under debris in and around bean fields. These adults attack germinating soybeans by chewing on the cotyledons, underground stems and the first sets of true leaves. Adults are about 1/5 inch in length, either reddish or tannish in color, and with or without 4 black spots on the back. Eggs are deposited in the soil around stems of beans. Larvae feed upon the smaller roots and eventually upon the nodules. Larvae are small, slender, white with brownish heads and brownish spot at the end of the abdomen. There are two generations annually over most of the state, except the Delta Counties may have a third generation. The adults are primarily foliage feeders, however, the last generation adults may occasionally turn to feeding upon blossoms, newly set pods, or developing beans within pods. Control measures are recommended only when pod damage is occurring.

2. Mexican bean beetle (adult and larva) is not known to be a pest of soybeans in Missouri, but probably will become so in years to come. Adults overwinter under debris, move to beans during late spring, and lay packets of yellowish-orange eggs on underside of leaves. Larvae and adults feed by stripping the green surface from underside of leaves resulting in a skeletonized or lacy appearance. There are two generations annually.

3. Japanese beetle is known to occur only within the City of St. Louis and St. Louis County, and here its numbers have been quite low since its introduction in 1934. The larval stage is found in the soil preferring to feed upon the roots of grasses. It overwinters as a partially grown grub. These larvae resume feeding in the spring, pupate in the soil, and emerge as adults during July. The adults are voracious feeders upon the foliage and fruits of numerous crops, ornamentals and flowers. Eggs are deposited in grassland during August. There is one generation annually.

4. Striped blister beetle, and other species of blister beetles, may occur in heavy numbers within localized areas of a soybean field during July and August resulting in rapid defoliation of infested spots. Usually, by the time the infestation is noted, the damage has been done and the beetles have dispersed to other localities. Blister beetle larvae are predators of grasshopper eggs, and therefore, populations are more abundant the year following moderate to high grasshopper numbers.

5. Green stink bug (adult and damaged soybean seed), some other species of stink bugs and broad-headed bugs, damage soybeans by inserting their beak through the pod and into the developing to nearly mature seed. Such damaged beans may be shriveled or show a small, sunken dark spot around the point of injury. Both nymphs and adults may cause this injury and both may transmit yeast spores resulting in yeast spot disease. Stink bugs overwinter as adults and have at least one generation on other favored hosts before moving into soybeans. There are probably two generations over the northern half while three generations occur over most of the southern half of the state. Stink bug problems on soybeans reach a peak during August and early September. A population of two or more immature or adult stink bugs per yard of row appears to justify control efforts.

6. Two-spotted mites and other spider mite species may injure soybeans by sucking sap from underside of leaves resulting in foliage becoming light yellow to bronzy, while heavy infestations may cause defoliation. The tiny mites move into soybeans from surrounding weedy fence rows or adjacent red clover. Spider mites multiply rapidly during hot, dry weather, therefore their damage is most common during July and August.

7. Thrips are small, slender insects that feed by rasping the underside of leaves, usually close to a vein, and then sucking up the exuding sap. This feeding leaves a thin, narrow, silvered streaking visible on the leaf surface. Thrips are most common during the early part of the growing season. This feeding injury has not been shown to cause yield losses, and control measures are not recommended.

8. Grape colaspis larva resemble a very small white grub. They feed upon the roots of seedling soybeans or corn following old stands of lespedeza or red clover. Root feeding may discolor, stunt, or kill seedlings. The partially grown larvae overwinter in the soil, complete larval growth in the spring, pupate, and emerge as adults during June and July. The adult beetle is small, oval, and tannish in color with minute ridges on the wing covers. These adults often eat small holes in the leaves of soybeans.

9. Seed maggots, usually seed corn maggots, may destroy the seed before it germinates, particularly during cool, wet weather. The adult flies are attracted to and lay their eggs in fields having large amounts of decaying organic matter on or near the soil surface. Rarely are stands reduced to the point necessitating replanting.

10. White grub is the larval stage of the May beetle. Most species of white grubs prefer the roots of various grasses, but a few species are known to attack soybean roots. Most species require three years to complete their life cycle. Damage most usually occurs following planting of crop in soils which were previously sod land.

11. Grasshoppers, nymphs and adults of several species, may feed upon the leaves and pods of soybeans, especially during a dry summer. Damage is usually confined to the marginal rows adjacent to fence rows, ditch banks, and grass land. Grasshoppers overwinter as eggs in the soil, hatch during May and June, and the partially grown to mature hoppers begin to move into crops during July and August when surrounding vegetation becomes scarce or matures.

12. Green cloverworm larva is light green in color with 5 faint white lines running the length of the body, and is just over an inch in length when full grown. They are primarily foliage feeders, although under outbreak situations where plants are largely defoliated, these larvae may turn to feeding upon blossoms and newly set pods. There may be three to five generations each year, but the generation that occurs during August and early September causes the most concern to soybean growers. Control measures are not suggested until 30-35% of foliage is destroyed. Larvae are often controlled naturally by a fungus disease and by a parasitic fly – note fly eggs behind head on illustration.

13. Cabbage looper and other closely related species of looper larva may occasionally cause some defoliation of late planted soybeans from July to September, especially in the southern counties. Looper larvae are light green in color, a little over 1 inch in length when full grown, gradually taper toward the head, and crawl with a distinct looping or measuring worm motion. There are several generations on other preferred host plants before moving to soybeans.

14. Garden webworm larvae most seriously damage young soybeans that are less than 10 inches in height, especially late planted soybeans. Larvae are about 3/4 inch in length when full grown, yellowish-green in color, with three black spots on each side of each abdominal segment. There are usually several larvae per plant which tie the leaves together with a thin silken web and feed by skeletonizing the foliage within this semi-protected area. There are at least three generations annually. Control measures are suggested whenever small beans show evidence of webworm infestation.

15. Corn earworm larvae may attack both foliage and pods of soybeans, especially over the southern counties. Newly hatched larvae feed upon terminal foliage for a few days before moving down to feed upon small pods and eventually upon the larger pods. Pod injury is most severe on mid-season and late planted beans during late August and early September. There are three generations annually, but the last generation is the one most likely to damage soybeans. Control measures are suggested when there is an average of one or more larvae per yard of row after pods are beginning to fill.

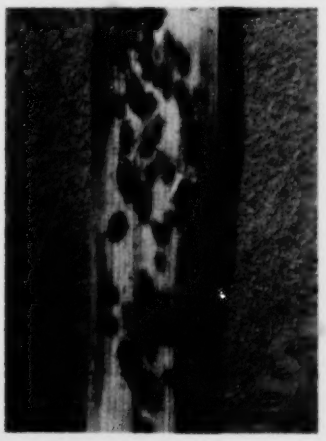
Issued in furtherance of cooperative extension work, acts of May 8 and June 30, 1914, in cooperation with the United States Department of Agriculture. C. B. Ratchford, Vice-President for Extension, Cooperative Extension Service, University of Missouri, Columbia, Mo. 65201.

Picture Sheet No. 7

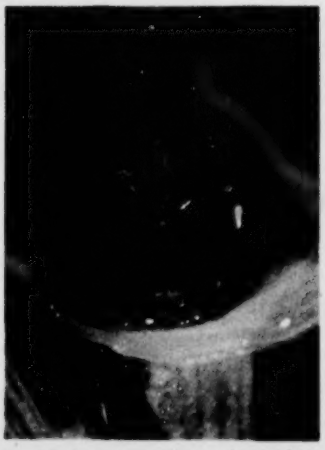
COMMON SMALL GRAIN INSECTS

For safe and effective use of insecticides, always identify the problem correctly.

1. Cereal leaf beetle adult, eggs, larva, and damage



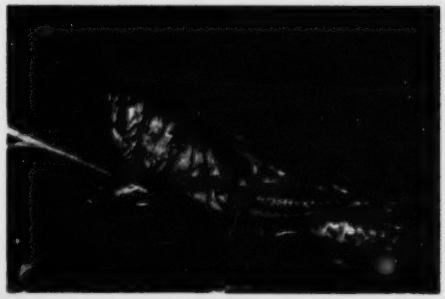
2. Greenbug and damage



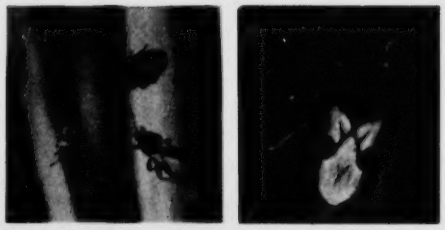
3. Thrips (greatly enlarged)

4. Hessian fly larva, and puparium showing location behind lower leaf sheaths

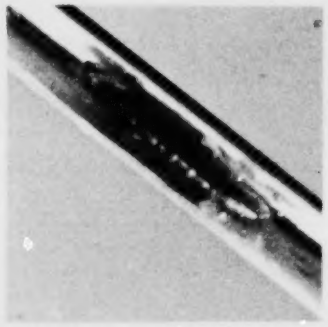
5. Armyworm



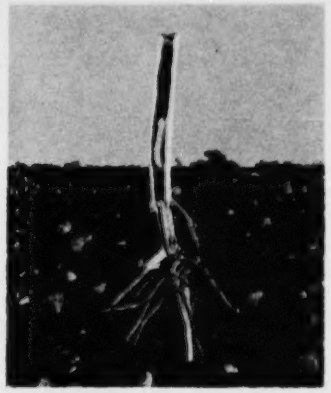
6. Grasshopper



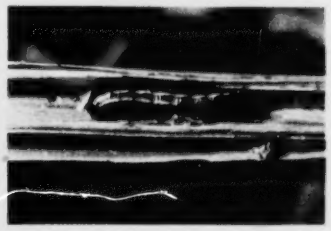
7. Chinch bug nymphs and adult, and adult greatly enlarged



8. Wheat stem maggot



9. Wheat stem sawfly



10. Common stalk borer

11. Wireworm and damage to seed

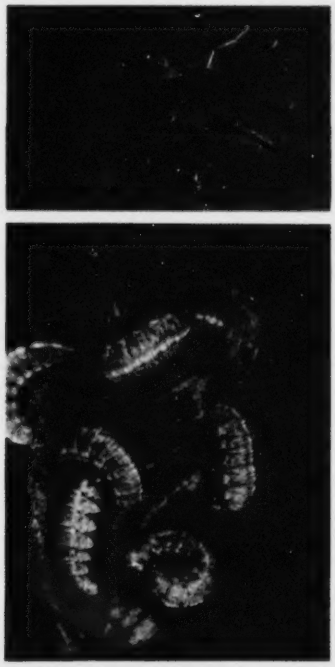
Prepared by Extension Entomologists of the North Central States in cooperation with the Federal Extension Service, U.S. Department of Agriculture

6j

Picture Sheet No. 8

COMMON FORAGE LEGUME INSECTS

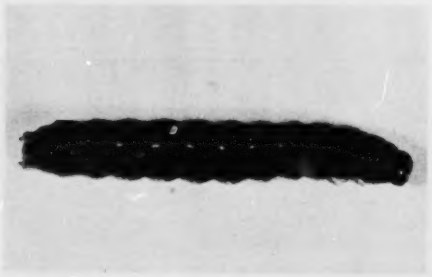
For safe and effective use of insecticides, always identify the problem correctly.



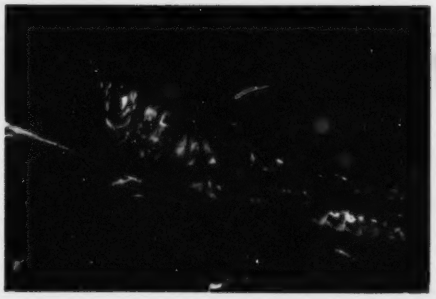
1. Alfalfa weevil adult, and larvae and damage

2. Clover leaf weevil larva

3. Sweet clover weevil and typical damage



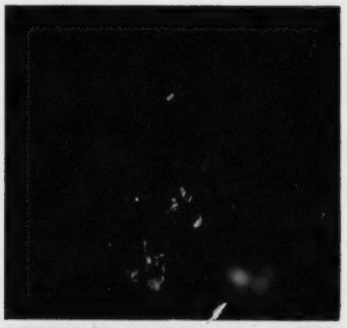
4. Varigated cutworm



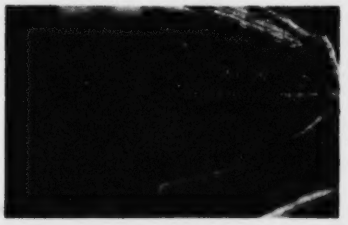
5. Grasshopper

6. Green clover worm

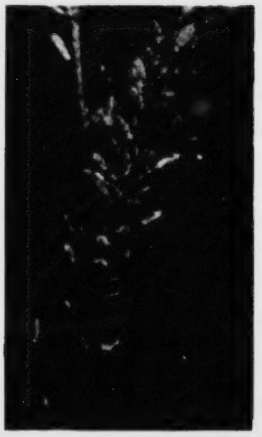
7. Potato leafhopper (greatly enlarged) and leafhopper damage to alfalfa



8. Meadow spittlebug and nymphs



9. Spotted alfalfa aphid



10. Pea aphid

Prepared by Extension Entomologists of the North Central States in cooperation with the Federal Extension Service, U.S. Department of Agriculture

6k

Common Forage Legume Insects

James L. Huggans, Department of Entomology, College of Agriculture

1. Adult alfalfa weevil—Overwinters in alfalfa. Females lay eggs in alfalfa stems from September through June. New adults leave alfalfa fields in June to estivate in field margins, woods, and other sheltered areas until fall when they return to alfalfa. Adults feed primarily on alfalfa, but will infest clovers and several other plants if alfalfa is not available. Adults are ¼ inch long, brown colored with a darker stripe down the back.

Alfalfa weevil larvae—The larvae shown are fully developed and ready to pupate for the change to adults. The larvae normally hatch in April, May, and June. Newly hatched larvae are yellowish with black heads. They imbed themselves in the growing tips of alfalfa stems. After several days feeding, the larvae turn green and have a white stripe down the back. When fully developed, the larvae are about ⅜-inch long. Chemical control of the larval stage is the best method of control available at this time.

Alfalfa weevil damage—Close inspection of infested fields in the spring is necessary to detect the beginning of leaf skeletonization caused by larval feeding. As more and more leaf tissue is removed, the field assumes a silvery appearance. Feeding may continue until stems are also eaten which may kill young alfalfa plants. Hay quality will be very poor if feeding damage reaches the degree shown.

2. Clover leaf weevil—A close relative of the alfalfa weevil occasionally injures alfalfa and red clover. These insects usually pass the winter as partially grown larvae and may be found at the base of plants during the day. The larvae are green with a pale white stripe edged with pink down the back. Full grown larvae are about ½ inch long. Adult weevils are twice as large as the alfalfa weevil and lay their eggs in September and October. Disease and a parasitic wasp keep this species in check most of the time.

3. Sweet clover weevil—Adult weevils commonly feed on all clovers, alfalfa and soybeans. The brownish beetles, about $^{1}/_{16}$ inch in length, have a short snout, eat out rounded areas in plant leaves, and may cause severe damage. The larvae are small grubs that feed on clover roots and crowns. Their damage usually goes unnoticed. When severe populations occur, rotation to grasses or cultivated crops will eliminate the infestation.

4. Variegated cutworm—Larvae of this pest are frequently found in alfalfa and other crops. The cutworm overwinters as a pupa. When fully developed the larvae measure 1-1½ inches long. They have pale yellow dots along the middle of the back, and often have a W on the eighth abdominal segment. The skin is smooth, generally ashen in color, or a light dirty-brown, lightly mottled with dark brown. Three to four generations occur.

5. Grasshopper—Several species of grasshoppers are commonly found in forages. Outbreaks severe enough to cause economic damage are usually associated with prolonged periods of drought. Undisturbed areas, such as fence rows, roadsides and pastures are the preferred habitats for early development.

6. Green cloverworm—Nearly always present in alfalfa and clover, the green cloverworm occasionally attains economically important numbers. It overwinters both in the pupal and adult stage. The adults are dark brown, black spotted or mottled moths with a wing spread of about 1¼ inches. The larvae are about the color of alfalfa leaves with two narrow white stripes down each side of the body. When fully grown, they are 1-1¼ inches long. Two to three generations probably occur in Missouri.

7. Potato leafhopper—This pest is known to feed on 100 cultivated and wild plants. The ⅛-inch-long, yellowish-green wedge shaped adults migrate into the state each spring. The females live a month or more and deposit 2-3 eggs a day in plant stems and leaf petioles. The eggs hatch in 10 days, and the yellowish green nymphs become full grown in about two weeks. The nymphs are similar in shape to the adults, but lack wings: They feed on the underside of the leaves, usually where they hatched. The leafhoppers pierce the leaf vein and suck the sap from the plant, causing the leaves to turn yellow. In dry seasons, the added stress of drought to "hopperburn" can cause serious damage to alfalfa plants, as well as loss of the current cutting. Two to four generations may occur in Missouri each year.

8. Meadow spittlebug—Nymphs are found inside the spittle masses in April, May, and June. They are pink when very young, but turn yellowish-green as they develop. Soon after hatching, the nymphs secrete a liquid (mostly plant sap) and force air through it to produce the spittle masses. The grey or mottled-brown winged adults, about ¼ inch long, emerge in June. Almost all damage is caused by the nymphs sucking sap from the plant.

9. Spotted alfalfa aphids—These plant lice are usually pale yellowish-green with six or more rows of black spots on their backs. The spotted alfalfa aphids seen on alfalfa are nymphs or winged and wingless females. Males are rare. Both adults and nymphs suck sap from the plants. Resistant alfalfa varieties, including Cody, offer adequate protection against this pest.

10. Pea aphid—These plant lice are usually dark green, darker than the spotted alfalfa aphid, and do not have spots on their bodies. Infestations may build up in April, May, and June. Predators usually hold the populations in check.

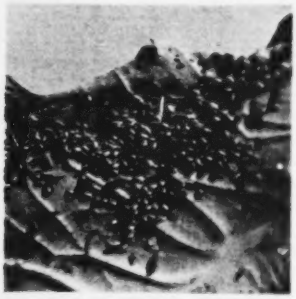
Issued in furtherance of cooperative extension work, acts of May 8 and June 30, 1914, in cooperation with the United States Department of Agriculture. Carl N. Scheneman, Vice-President for Extension, Cooperative Extension Service, University of Missouri, Columbia, Mo. 65201. The University of Missouri-Columbia is an equal employment and educational opportunity institution.

File: Ent. 6/73/10M

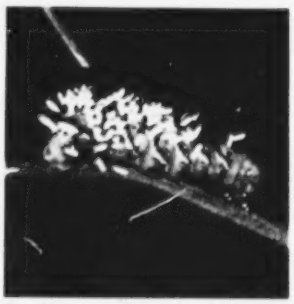
COMMON VEGETABLE INSECTS

For safe and effective use of insecticides, always identify the problem correctly.

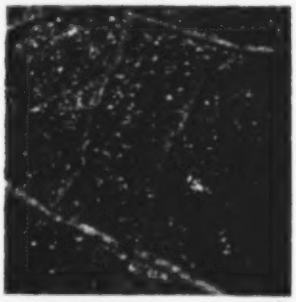
1. Cabbage looper (light green) and imported cabbageworm (dark green)



2. Cabbage aphid. Other species damage many crops.



3. Hornworm showing cocoons of parasite on back



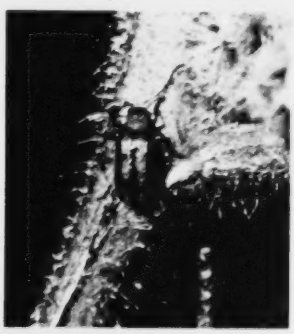
4. Two-spotted spider mite (enlarged). Not an insect.

5. Bean leaf beetle

6. Mexican bean beetle adult, pupa, larvae, eggs, and damage

7. Thrips (enlarged)

8. Root maggot and damage



9. Striped cucumber beetle

10. Spotted cucumber beetle

11. Colorado potato beetle larvae and adults

12. Potato flea beetle and damage

13. Potato leafhopper (greatly enlarged) and leafhopper damage

14. Squash vine borer and damage

15. Squash bug nymphs and adult

Prepared by Extension Entomologists of the North Central States in cooperation with the Federal Extension Service, U.S. Department of Agriculture

6m

Common Vegetable Insects of Missouri

Wilfred S. Craig, Department of Entomology,
College of Agriculture

1. CABBAGE LOOPER AND IMPORTED CABBAGEWORM—These caterpillars damage cabbage and other plants in the mustard family by feeding on the leaves. The cabbage looper overwinters as a pupa in a flimsy cocoon attached to or near the host plant. The grayish-brown moth with a wing spread of about 1½ inches, and with a silvery spot near the center of each fore wing emerges in the spring. The round greenish eggs are deposited on the underside of leaves on the host plants. The greenish larvae hatch from the eggs and measure about 1 inch in length when fully developed. There are three to four generations in Missouri. The late summer and fall generation usually causes the most damage.

The imported cabbageworm is the caterpillar of the common white cabbage butterfly frequently seen in gardens. The winter is spent as a chrysalis. The adult emerges in April and deposits the small yellowhish, bullet-like eggs on the leaves of cabbage and other cole crops. The velvety green larvae hatch and feed on the leaves. When mature they measure about one inch in length. There are four to five annual generations in Missouri.

2.CABBAGE APHID—This "plant louse" overwinters as a shiny black egg on plant refuse. The soft-bodied greenish aphid hatches in spring and sucks sap from the host plant. They may produce eight to ten generations in Missouri, however, usually the spring and fall generations are the most damaging.

3. HORNWORM—These are the best known insect pests of tomatoes. The large green caterpillars, three to four inches long, with the white slant-marks on their sides and the slender reddish or blackish horn near the rear end are the larvae of large hawk moths. This insect overwinters as brownish pupae in the soil. There are two generations each year. The white cocoons on the larva pictured are those of a small braconid wasp parasite which have developed inside the larva.

4. TWO-SPOTTED SPIDER MITE—These very small pests of garden plants suck sap from the leaves and stems causing flecking, and wilting of the foliage. During dry, hot weather population buildup and plant damage can occur rapidly.

5. BEAN LEAF BEETLE—The larvae and adults feed on beans. The adults, about 1/5-to 1/4-inch long, usually reddish or yellowish in color and with black spots on the wing covers, hibernate during the winter and are ready to attack the beans in the spring. Eggs are placed in the soil around the bean plants. The larvae hatch and feed on the roots. Pupation takes place in the soil. There are two generations in Missouri.

6. MEXICAN BEAN BEATLE—The larvae and adults feed on the underside of bean leaves. The adults overwinter in protected places near bean fields. These beetles are 1/4-to 1/3-inch long, coppery-brown in color, almost round and with arched wing covers. Each wing cover has eight black spots arranged in three rows. The orange-yellow eggs are fastened on end in groups of 30 to 50 to the underside of leaves. The larvae hatch and are about 1/3 inch long when full grown, yellow in color and have six rows of branching spines on their backs. There are two generations each year.

7. THRIPS—These tiny insects, about 1/25 inch long, overwinter as adults and nymphs in plant debris. There are several species which attack garden plants. They rasp the surface of plants and suck the exuding sap. The onion thrips frequently cause severe browning of onion leaves and distortion of the bulbs.

8. CABBAGE MAGGOT—Roots of turnips, cabbage and radishes are sometimes tunnelled by this fly maggot. This pest overwinters in the soil as a pupa. The adult fly, about 1/4 inch long, emerges in May and deposits eggs near the host plant. Late planted crops usually suffer the most damage from this insect.

9. STRIPED CUCUMBER BEETLE—Seedling cucumbers, melons and squash are attacked by the overwintering adults of this insect. The eggs are laid around the stems of the plants and the elongate white larvae feed on the roots. Pupation takes place in the soil. The adult beetle is about 1/5 inch long with the upper surface yellow striped with black. There are two generations each year in Missouri.

10. SPOTTED CUCUMBER BEETLE—Also known as the Southern corn rootworm beetle. Like the striped cucumber beetle it feeds on cucurbits and carries the organism which causes cucurbit wilt. The insect overwinters as an adult. There are two generations each year in Missouri.

11. COLORADO POTATO BEETLE—Both the larvae and adults of this insect feed on potatoes and other solanaceous plants. There are two generations each year. The adult overwinters in the soil.

12. POTATO FLEA BEETLE—This very small black beetle eats small holes in the leaves of potatoes. When disturbed, it jumps from the plant. Slow growing plants are frequently severely injured. The winter is spent in the adult stage.

13. POTATO LEAFHOPPER—These very small greenish-white insects suck the sap from potatoes and many other species of plants. Conditions referred to as "hopper burn" and yellowing often result from their feeding. The adults overwinter in the gulf states.

14. SQUASH VINE BORER—The larvae are borers in the stems of pumpkin and squash. Plants attacked frequently wilt and die during late summer. The winter is spent as a larva in a tough cocoon in the soil. The wasplike adult moth emerges in late spring. There is one generation in Missouri.

15. SQUASH BUG—Adults and nymphs of this common pest of squash and pumpkins suck the sap from the plants. There is one generation each year. The adults hibernate during the winter.

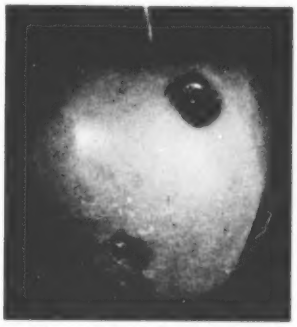
Issued in furtherance of cooperative extension work, acts of May 8 and June 30, 1914, in cooperation with the United States Department of Agriculture. C. B. Ratchford, Vice-President for Extension, Cooperative Extension Service, University of Missouri, Columbia, Mo. 65201.

6 of 7

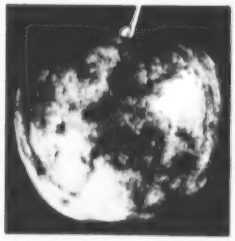
Picture Sheet No. 10

COMMON FRUIT INSECTS

For safe and effective use of insecticides, always identify the problem correctly.



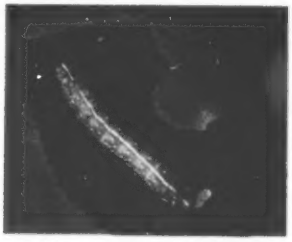
1. Codling moth adult and new larval entry, and damaged or "wormy" apple



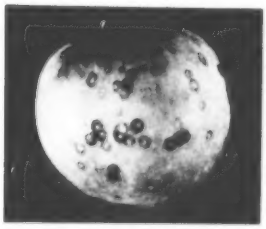
2. Apple maggot in apple, and blotching and streaking of maggot-infested fruit

5. Rosy apple aphid, and deformed fruit shown with normal apples for comparison

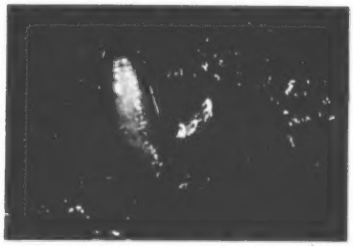
3. Red-banded leaf roller and damage



4. Green fruitworm

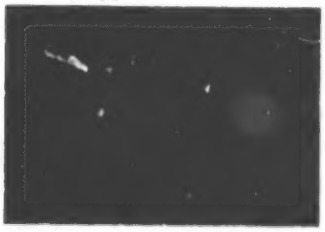


6. San Jose scale on apple



7. Cherry fruit fly maggot

8. Plum curculio adult and egg-laying slit on cherry, and curculio larva in plum



9. Two-spotted spider mite and eggs (enlarged). Not an insect.

10. Grape berry moth larva and damage

11. Oriental fruit moth. Twig damage and larva in peach.

12. Peach tree borer and pupa

25

Prepared by Extension Entomologists of the North Central States in cooperation with the Federal Extension Service, U.S. Department of Agriculture

6-70

Common Fruit Insects of Missouri

Wilfred S. Craig, Department of Entomology, College of Agriculture

1. CODLING MOTH—This insect has always been a serious pest of pome fruits. The winter is spent as a mature larva within a cocoon under bark, in twigs or in trash usually near the orchard. Pupation takes place early in the spring and the moths begin emerging in early May. Egg laying is usually finished within 3-4 weeks following apple bloom. The larvae hatch from the eggs, feed a short time on leaves, then bore into the small apples. The larvae, white to pinkish in color, reach maturity about mid-June, pupate and the second generation adults begin emerging in late June. Third generation adults start emerging in early August.

2. APPLE MAGGOT—The larva of a small picture-winged fly has not been reported a pest in Missouri. Due to the winding route of the maggot in the fruit of apples, is often referred to as the "railroad-worm".

3. RED-BANDED LEAF ROLLER—The winter is passed as a pupa in a cocoon. The small, brownish, red banded, overwintering generation moths, emerge and lay eggs early in the silver tip stage of apple tree development. The eggs hatch and the larvae feed on the leaves and young fruit. The larvae reach maturity in late May and pupate. First generation moth flight starts in early June. Second generation moths are still present in July and the third generation moths are present in August and September. Some of the third generation larvae develop slowly, pupate and overwinter. Some pupate and fourth generation moths frequently emerge in September and deposit eggs. Larvae of this generation pupate in November and December.

4 GREEN FRUITWORM—Large holes are frequently eaten in young apple fruit by the green fruitworm, the larva of a grayish moth. The winter is passed in protected places as a grayish moth or as a pupa in the soil. Eggs are deposited by the moth in the spring and the pale green larvae reach maturity in early June.

5. ROSY APPLE APHIDS—These soft bodied pests of apples pass the winter as dark green eggs in cracks in the bark of the tree. When the young aphids hatch from the eggs in early spring they crawl to leaf buds and start to suck sap from the plant. Feeding by the aphids cause the developing leaves to form a cluster of curled leaves or "rosette". Young aphids are produced, develop wings and leave the apple during the summer. Some return in the fall to lay eggs for the winter.

6. SAN JOSE SCALE—One of the many scale insects that cause serious damage to fruit trees. The winter is passed as nymphs, under small, blackish scales. They continue development in the spring and mature about apple blossom time. The oblong scales range in sixe from 1/12 to 1/25 inch and have a black nipple near the center. The female insect gives birth to young. As many as 5 generations may develop in one season.

7. CHERRY FRUIT FLY—This pest of cherries apparently does not cause trouble in Missouri. The larvae of this picture winged fly bore into the fruit, feed, and reach maturity about the time of fruit ripening. The mature larvae drop to the soil to pupate.

8. PLUM CURCULIO—This serious pest of stone and pome fruits passes the winter in the adult stage. The stout, dark brown, snout beetles about ¼ inch long, cuts crescent shaped gashs in the developing fruit and deposit eggs. The eggs hatch in about 10 days into legless white larvae which bore into the fruit. Infested plums usually ripen earlier than normal. Pupation takes place in the soil. The summer generation adults emerge during July and feed on fruit before seeking a place to spend the winter.

9. TWO-SPOTTED MITE—This small mite spends the winter in trash, under bark and protected parts of plants in the nymphal stage. It begins feeding whenever the temperature warms up in the spring. When grown it deposits a number of pale eggs on the leaves of the host plant. Many generations of mites can be produced each season, however peak populations usually occur during dry periods of the year from mid summer into fall. Since the pest feeds by sucking sap from the plant, infested leaves become pin-point spotted and appear dull gray-green to bronzed.

10. GRAPE BERRY MOTH—This insect feeds on the fruit of the grape. The pest passes the winter as a pupa in a cocoon in grape leaves and trash near the vineyard. The grayish-purple moth with a wing spread of about ½ inch, emerges in late May and deposit eggs on leaves, flower or fruit clusters. The larvae hatch, web the berries together and eat holes in some. When mature, the dark grayish-green larvae, ⅓ to ½ inch in length, spin their cocoon in a leaf fold and then pupate. The second generation moths emerge about mid-July and start the cycle again. Pupae of this generation usually overwinter.

11. ORIENTAL FRUIT MOTH—This insect, a serious pest of peach and plum and to a lesser extent of other fruit, passes the winter as a larva in a cocoon on the tree trunk or in trash near the tree. Pupation takes place in the spring and the dark brown moth, with a wing spread of about ½ inch, emerges in early spring. Eggs are deposited on the buds, hatch and the larvae bore into the developing twig tips. The larvae mature, pupate and the moths emerge. There are several, probably 4 or 5, generations per year. When the fruit is developing it becomes a prime target of the pest.

12. PEACH TREE BORER—This insect is a serious pest of the peach, apricot, plum and cherry trees. It spends the winter in the larval stage just under the bark of the lower trunk of the infested tree. Pupation takes place in a frass covered cocoon in the soil near the tree. The adults moths are wasp-like in appearance. The female is blue-black with two red abnormal segments while the male is nearly clear-winged with several yellow bands around the abdomen. They begin to emerge in late June and continue emerging throughout the summer. There is generally one generation each year.

Issued in furtherance of cooperative extension work, acts of May 8 and June 30, 1914, in cooperation with the United States Department of Agriculture. C. B. Ratchford, Vice-President for Extension, Cooperative Extension Service, University of Missouri, Columbia, Mo. 65201.

DISEASES AND NEMATODES

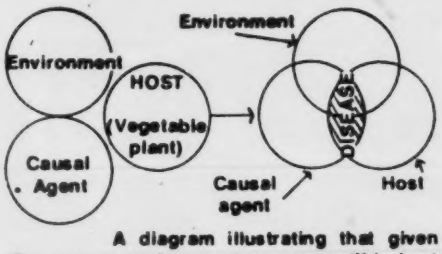
Broadly speaking, a plant is said to be diseased when it is continuously affected by some factor which interferes with its "normal" structure or activities. Disease usually produces some outward signs and/or symptoms. The inclusion of the word "continuously" excludes such things such as insect injury.

Disease is a term usually reserved for those problems caused by parasites: fungi, bacteria, nematodes, viruses, mycoplasmas and parasitic seed plants. Some non-parasitic disorders caused by agents other than parasites are often confused with diseases. These problems are caused by such things as unbalanced fertility, toxic chemicals and air pollution. They often resemble diseases caused by certain parasites. For example, certain types of spray-burn look much like some leafspot diseases. In many instances, it is difficult to determine the cause without several days of laboratory work.

Symptoms and signs of a disease are the basic keys to plant disease identification. A "symptom" of a disease is the reaction of the host plant to invasion by the parasite or injury from the non-parasitic factors: spots on the leaves or wilting. A "sign" is physical evidence of the pathogen (parasitic causal agent): for example, visible growth of fungus mycelium fruiting structures, spores, etc.

All disease symptoms and signs are a result of an interaction between the host plant, the pathogen, and the environment. Some specific pathogens are able to attack a number of different plant species. And the symptoms of the disease may be entirely different

on each different plant. A further problem--diseases caused by nematodes may have no visible above-ground symptoms if soil moisture is adequate.



A diagram illustrating that given the proper environment, a susceptible host and a causal agent, disease develops.

Over 80,000 different parasitic diseases attack plants. Of course, no crop has this many. Some have only half a dozen common diseases; others have many more. Tobacco has over 70 different described diseases. Only a few of these diseases occur commonly and cause serious economic problems. The fact that the less common diseases do occasionally occur complicates accurate disease diagnosis. Quite frequently, a plant may have two or more diseases at the same time.

Accurate identification and diagnosis is an art as well as a science. Experience is important. This outline is not intended to make anyone an expert in identifying diseases. In an outline of this type, it is impossible to cover even the major disease problems of individual crops. The discussion is to acquaint you with the general symptoms that occur as a result of disease to help applicators determine, for example, whether the symptoms are a result of the pathogen attacking the leaves or the roots.

Fungus and bacterial diseases are grouped into symptom classes; virus and nematode diseases are covered under the causal agent.

Leaf Diseases

These diseases occur primarily on leaves, but some may also occur on stems and/or fruit. Leaf diseases are the most common diseases of most plants. Although leaf diseases are described under several different symptom types, keep in mind that differences are not always clearcut. And many names exist for leaf diseases other than those given, which can sometimes be confusing. They are usually controlled with fungicides, sanitation, and by planting resistant varieties.

Leaf Spots -- Leaf spots are mainly caused by bacteria and fungi (other names: anthracnose, scab, leaf blotch, shot hole) producing rather definite spots of varying sizes, shapes and colors. Look for the usual distinctive margin. Sometimes the spot is surrounded by a

Figure 1. Common leafspot (*Pseudopeziza medicaginis*) of alfalfa is typical of a leafspot disease. It is characterized by small, circular, dark brown spots, about 1/16 inch in diameter, on the leaflets. There are also several other leaf spot diseases on alfalfa.

yellow halo. Fungus-caused spots usually have a fungus growth of some type in the spot, particularly in damp weather. There may be tiny pimple-like structures, often black in color; or a moldy growth of spores. It is often necessary to use a hand magnifier to see these structures at all. If the spots are numerous or close together, diseased areas may join together to form irregular areas called "blotches". The common names of leaf spot diseases may be named for the crop, such as peanut leaf spot; descriptive, such as zonate leaf spot; or named after the fungus, such as Septoria leaf spot.

Leaf Blights -- Leaf blights are generally larger diseased areas than leaf spots and more irregularly shaped. Usually the common name includes the word "blight" such as Northern or Southern corn leaf blight or bacterial blight of soybean.

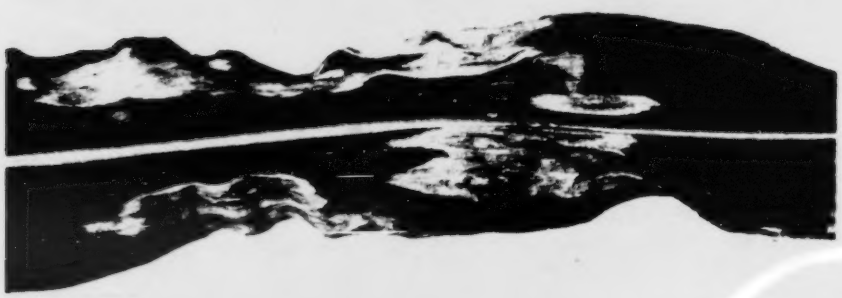


Figure 2. Helminthosporium leaf blight of corn. The most common is Northern corn leaf blight which is distinguished by gray-green elliptical spots scattered over the leaf surface.

Rusts -- Rusts are fungus diseases that often produce leaf spots, but the spots are called "pustules". Rust pustules may be bright yellow, orange-red, reddish-brown or black in color depending on the rust species or maturity of the pustules. The pustules are usually raised above the leaf surface. When rubbed with a white cloth, they usually leave a colored deposit the same color as the pustule. In severe cases, the leaf withers and dies rapidly. Some types of rust also occur on stems such as the black stem rust of wheat. Rusts are most common grains and grasses, (such as crown rust of oats), fruits (such as cedar-apple rust), ornamentals (such as rose rust), and vegetables (such as asparagus rust).

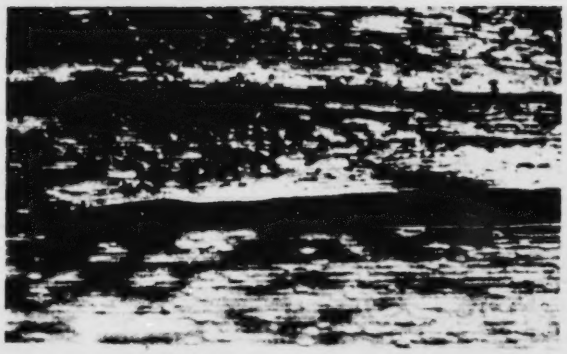


Figure 3. Leaf rust of wheat and other small grains is characterized by pustules that are filled with a mass of brick red spores.

Powdery Mildew -- Powdery mildew is a superficial fungus disease characterized by a white to light grayish, powdery to mealy growth on leaves. It also may occur on stems and flowers. Affected leaves usually turn yellow, wilt and die rapidly. It is commonly found on cucurbit-type vegetables, small grains, several ornamental species, and shade trees.

Downy mildew -- Downy mildew is a fungus disease causing pale green to yellow areas on the upper leaf surface and light gray to purplish moldy growth on the under surface of the leaf. It is important on several vegetables, forage legumes, corn, soybeans, and other crops.

Figure 4. Powdery mildew diseases are identified by a superficial white moldy growth on the leaves. They can be seen on many species of plants.

Figure 5. Downy mildew infections can be seen on many different plant species. Downy mildew can be readily seen on soybeans first as yellow-green spots on the upper leaf surface; a grayish mold on lower surface. Later the spots turn brown.

Wilts, Root and Crown Rots.

These are three distinct types of diseases, but they often show similar overall symptoms (wilting and death of the plant). However, other symptoms are not similar and close examination of a plant with wilting symptoms will nearly always allow one to determine if it is a wilt, a root rot or crown rot. These diseases are usually soil-borne (the causal organism is already present in the soil when the host is planted) as opposed to most other diseases (except nematode diseases) which are usually spread through the air. Some of these diseases may be controlled through the use of soil fungicides and/or soil fumigants, but most are controlled by using resistant varieties and certain cultural practices. Effective controls are not available for many of these diseases.

Wilts -- Most wilts are caused mainly by two fungi: Fusarium and Verticillium and a bacterium, Pseudomonas. All of these cause wilts on a wide range of crop plants. Pathogens that cause wilt diseases enter the plant through the roots. Some of the roots may be black and rotten in the early stages of disease, but the extensive root rotting as in

Figure 6. Fusarium wilt is found on a wide range of crop plants. The above ground symptoms are yellowing and wilting.

the root rot diseases does not occur until after the plant is dead. When a stem of a plant with one of these diseases is cut lengthwise, a light to dark brown streaking can be seen in the stem. It is often difficult to determine which of these wilt diseases a plant may have, but certain distinguishing characteristics will usually make a reasonably accurate diagnosis possible. Verticillium wilt normally occurs in cooler areas with lower soil temperatures than do the other two wilts. For example: Verticillium wilt of tomato is more prevalent in northern states than in southern states. However, Verticillium wilts also will vary depending on the host and fungus species. Plants with Fusarium or Verticillium wilt are usually slower growing than healthy plants and may show stunting effects before wilting occurs. The lower leaves usually turn yellow and wilt first. Then yellowing and wilting slowly progress up the plant. Several days to a few weeks may elapse between first evidence of wilting and death of the plant. In contrast, plants with bacterial wilt usually die within a few days after the first wilt symptoms are seen. Also plants with bacterial wilt often exhibit a one-sided wilt. Leaves or

Figure 7. Stewart's disease or bacterial wilt can cause serious wilting symptoms in susceptible varieties of sweet corn.

branches on one side of the plant are wilted while the opposite side appears healthy. Fusarium wilt is often a "complex" or interaction between the host plant, the fungus and nematodes. The fungus may be present in the soil, but will not cause disease unless nematodes attack the roots. However, Verticillium and bacterial wilts are also usually more severe when nematodes attack the roots. Fusarium and Verticillium wilt are important diseases on cotton and many vegetables. Bacterial wilt is important on tobacco and several vegetables.

Crown and Stalk Rots -- This includes those diseases in which the causal organism attacks the plant at or near the soil line. Several fungi are involved. Crown rots

Figure 8. Rhizoctonia root and stem rot is common to many agricultural crops, especially the legumes. Dark brown sunken cankers near the ground line, if large enough, can cause girdling and death to soybean plants.

include common names such as collar rot, stem rot, stalk rot, and Southern blight. Affected plants are generally unthrifty, at first, with leaves smaller and lighter green than normal. Leaves usually turn yellow and in advanced stages of disease wilt and die. The crown or base of the stem may be watersoaked, discolored, or decayed. With some crown rot and stalk rot diseases, this area may have dry rot and become shredded. A moldy growth and various types of fruiting structures often form in this diseased area. Most crops are affected by one or more of these types of diseases.

Root Rots -- Above ground symptoms of these diseases vary. Some plants may show wilt type symptoms and die rapidly. Others are yellow, stunted, slow growing and may not die for some time after the first symptoms are seen. Roots are reduced in size and will be light brown to black and rotton. All plants may be affected by root rots, depending upon the environment.

Figure 9. Root rots are often characterized by discolorization of root parts and absence of small feeder roots. Several fungal species may be responsible. Fusarium species cause dry root rots.

Stem Cankers --

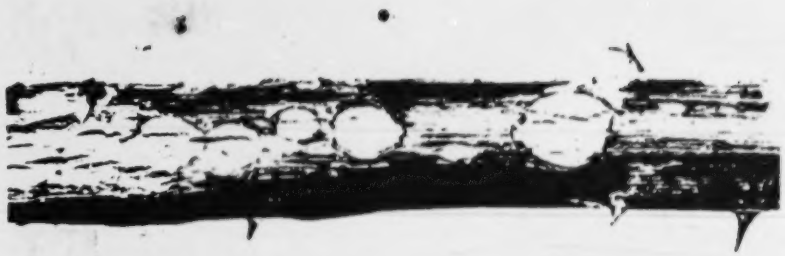


Figure 10. Stem cankers are diseased areas on main stems and branches -- irregular or oval in shape depending on causal agent. Anthracnose of brambles is a stem canker disease that causes more damage than any other disease on brambles

Stem cankers are diseased areas on main stems or branches showing definite discolored areas. These areas may be irregular or oval in shape or they may be sunken or swollen. Some cankers may crack open and expose the wood underneath. The foliage on plants having stem cankers is usually slow growing and reduced in size. Infected stems often start growth later in the spring than normal stems. Sometimes the tips of infected stems die back. Infected branches and plants may not die for several months or even years after the disease first develops. Stem cankers are most important on woody perennial plants. These diseases are controlled by careful pruning, sanitary practices, and to some extent, by certain fungicides, when used in combination with other agricultural practices.

Fruit Rots -- These diseases are caused by many different fungi and bacteria and occur on all types of fruit. The symptoms vary from a more or less superficial fungus growth on the external surface to a com-

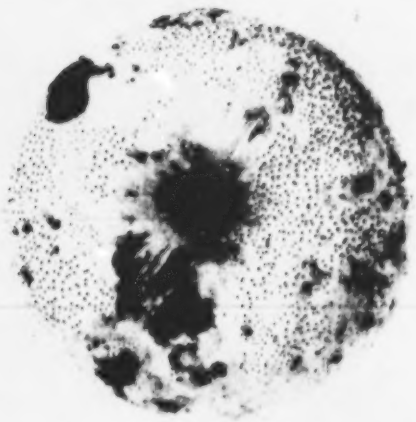


Figure 11. Sooty blotch (the larger irregular areas) and fly speck (the tiny dots) are superficial fruit rot infections. The fungi do not penetrate deeply.

Figure 12. Bitter rot of apple is a fungus disease that first appears as a small light brown circular area. The spot enlarges rapidly, becoming definitely circular and sunken in the center.

plete, mushy rot of the fruit. Fruit rots may develop while the fruit is still on the plant or in shipment and storage. These infections may be small scattered spots or involve the entire fruit. Many of these spots may be sunken below the surface and contain spores or other fungus fruiting bodies. Some types of fruit rots may cause shrivelling of the fruit and dry rot. Many are specific only on certain fruits; others may occur on many different fruits. One of the most important of all plant diseases is a fruit rot called bacterial soft rot which occurs on almost all fruit. It is also important on vegetables. Usually occurring only after an injury, soft rot is characterized by a rapid, mushy or watery, foul-smelling rot. Fruit rots are controlled to some extent by fungicides, sanitation and proper storage conditions.

Seed and Seedling Diseases.

By definition, these diseases occur on plants only in the early stages of development. Seed diseases are caused by fungi which may be on the seed at planting time or by fungi in the soil. They are often responsible for non-emergence or slow emergence. Seed may have a dry rot or a wet-mushy rot. Seedling diseases occur after germination prior to emergence. If the disease occurs before emergence, the seedling may rot before it has a chance to get out of the soil. After emergence, seedling stems may be attacked right at, or slightly below, the soil line.

Two general symptoms occur at this time: the first symptom is brown to reddish-brown or black cankers at the soil line that may completely girdle the stem. If complete girdling occurs, the seedling falls over and dies. This is known as "damping off". With partial girdling, the plant may continue to live, but often will be stunted. The second symptom is a soft, watery rot at the soil line. Eventually, the entire seedling rots. Seed and seedling diseases are most common in cool, wet soils. They are controlled by planting in a warm soil, using seed treatment fungicides, and/or in-furrow fungicides.

Virus Diseases

This group includes a very wide range of diseases caused by viruses. Certain diseases once thought to be caused by viruses have now been shown to be caused by a group of organisms called Mycoplasma. Almost all plants may have one or more virus or mycoplasma diseases. A very wide range of symptoms exists. It is often difficult to distinguish between

virus diseases and certain diseases caused by fungi, bacteria and nematodes as well as problems caused by environment, nutrition and other factors. It is impractical to describe all the different symptom types but some of the more common symptoms include:

Mosaic -- a light green to yellow leaf mottling usually accompanied by abnormal leaf growth.

Figure 13. Soybean mosaic is one of the most common mosaic type viruses--characterized by the dark and light green mottling. The leaves of infected plants are often distorted and puckered.

Vein banding -- a light green to yellow band around the leaf veins which may turn dark with time.

Ring spot -- alternating rings of light green or yellow bands with the normal green of the leaf.

Figure 14. Yellow mosaic of soybean is less conspicuous than common mosaic because there is less distortion and puckering. Younger leaves show a yellow mottling.

Yellows -- the entire plant or some parts turn uniformly yellow. Stunting usually accompanies all of the previous symptoms, or stunting may be the only symptom. Some virus diseases do not show any visible symptoms other than a yield reduction. Many virus diseases are transmitted from plant to plant by insects, some are transmitted by grafting and others are transmitted by other mechanical means. Virus diseases are difficult to control. Some are controlled by resistant varieties, using virus free seed or planting stock. Others may be controlled by controlling the insects that transmit the disease.

Nematode Diseases

All plants are attacked by one or more types of nematodes. Diseases caused by nematodes can be very im-

portant. Nematodes cause several hundred million dollars loss in the United States annually. It may well be that if we could accurately measure losses from these pests, losses would be considerably higher. This is because nematode damage often goes unrecognized or is blamed on other problems.

Figure 15. Root-knot nematodes attack a wide range of crops. The symptoms are characterized by galls or knots on the roots.

All important nematodes feed on plant roots. This directly interferes with water and nutrient uptake. This root injury causes above-ground symptoms similar to those produced by other conditions that damage the root system. Plants frequently appear to be suffering from lack of moisture or fertilizer, even when water and fertilizer are adequate. Typical above-ground symptoms are stunting, yellowing, loss of vigor, and general decline. Plants can die when nematodes occur in high populations.

Nematode injury in the field is rarely uniform.

Symptoms usually appear in small, scattered areas. Nematode symptoms are usually more obvious when soil moisture and fertility are low. Nematode damage to root systems in the presence of other parasitic diseases often cause more severe disease symptoms.

When nematodes are suspected, you should always examine the roots and take soil samples.

Figure 16. Nematode types other than root-knot often cause a reduced root system or complete lack of feeder roots.

To examine the roots, always carefully dig up the plants. Never pull the plants up as the rootlets affected by the nematodes may be lost. Nematode symptoms on the roots depend on the type of nematode causing the injury. Usually the symptoms will be one or more of the following: galls or knots, tiny brown to black lesions, stubby-roots and complete loss of feeder roots.

Many other problems can cause symptoms similar to

nematode injury. For this reason always take soil samples when nematode injury is suspected.

Take samples from around the edge of the suspect area, within the root zone. Use a soil sample tube and take soil down to a depth of 6-8 inches. Make at least 10 random probes per acre. Mix all of the soil in a plastic bag. Send to the Extension Plant Disease Diagnostic Laboratory through your County University Extension Center.

Nematodes are controlled with cultural practices, resistant varieties and nematicides.

WEEDS

Weeds are a major factor reducing crop yields. Weeds reduce yields through competition for light, moisture and nutrients. Heavy weed growth present at harvest also can cause severe harvest loss due to inefficient operation of harvesting equipment.

Figure 17. Horsenettle. A, Habit; B,flower; C,berries; D,seeds. Perennial weeds such as horsenettle often are difficult to control in cropland.

Weeds can be grouped into four broad categories on the basis of taxonomy.

For specific response of weeds to various herbicides used on row crops, refer to state extension recommendations.

Perennial and Biennial Weeds

Weeds of this category are generally difficult to control and require special control procedures. Often treatment procedures must be applied two or more years in row crops, pastures and tree crops to achieve satisfactory control. Examples of perennial weeds include johnsongrass, horsenettle, wild garlic, curly dock and bindweed. Examples of biennial weeds include common mullein and wild carrot.

Figure 18. Wild Carrot. A, Habit; B, pistillate spikelet; C, utricle; D, seeds. Wild carrot, a biennial, is not a problem in row crops.

Figure 19. Crabgrass. A, Habit; B, spikelet; C, seeds. Crabgrass, a small-seeded weed, can be controlled by several preemergent herbicides.

Annual Grasses

Weeds of this category are usually readily controlled with pre-emergence herbicides (preplant incorporated or surface applied). Certain weeds of this category are more difficult to control than others. For example, fall panicum and foxtails are controlled more readily with certain preplant incorporated herbicides (dinitroaniline herbicides) than with surface applied herbicides. Examples of common annual grass weeds include crabgrass, goosegrass, foxtails, fall panicum, and sandbur.

Small-seeded Broadleaf Weeds

These weeds are generally controlled well with the same herbicides which control annual grasses. Examples of this group include pigweeds, lambsquarters, water hemp, prickly sida, etc.

Figure 20. Redroot pigweed. A, Habit; B, pistillate spikelet; C, utricle; D, seeds. Small-seeded broadleaf weeds such as pigweeds are generally controlled by soil-applied herbicides.

Large-seeded Broadleaf Weeds

These weeds are not consistently controlled by pre-emergence herbicides (preplant incorporated or surface applied). Presently, these weeds and perennial weeds are the most difficult to control in most crops. Examples include cocklebur, velvet leaf, and jimson weed.

Figure 21. Common cocklebur. A, Habit; B, seedling, C, bur; D, seed. Large-seeded broad-leaf weeds such as common cocklebur are often difficult to control.

PESTICIDES

Pesticides are used to reduce populations of damaging pests. Unfortunately, pesticides sometimes have undesirable effects on non-target organisms. Therefore, they should only be used when benefits are greater than the undesirable side effects.

Formulations and Sources of Information

Pesticides are formulated as emulsifiable concentrates liquid concentrates, flowable liquids, wettable powders, soluble powders, dusts, granules and baits. Generally the type of formulation used is not important as long as it can be uniformly applied to the area where it is needed in the concentration required. In some instances, however, the type of formulation is important. State Extension recommendations usually explain the need for a specific formulation. All states have publications available through County Extension Offices that are excellent sources of information on pesticides. They include recommended pesticides, how they should be applied, safety precautions and restrictions, and how to best time applications. State Extension specialists

are available through county offices to assist with any problems that cannot be handled by the local staff.

The label on the pesticide container gives most of the information needed in using the pesticide. It should be carefully studied before each use of the chemical.

Application

Pesticides are applied in several different ways. Spraying is by far the most common method. However, other common methods include applying dusts, granules, spreading baits, and releasing chemicals that turn into gas for fumigation. In the fields, pesticides are applied broadcast, in bands, directed at the plant bud, directed under the canopy to the soil surface, mixed uniformly into the soil and even turned down. The type of application needed depends on the pest that needs to be controlled with a single application of pesticide. A compromise method may be chosen that is the best for the complex, although, not as good for one or more of the pests present. Extension specialists can usually furnish information on the best method of application to reach the desired goals.

Insect Control Chemicals

Insecticides are pesticides used to control insect pests. Most of the commonly used insecticides are classified as chlorinated hydrocarbons, organo phosphates or carbamates. They are synthetic organic chemicals, classified according to their chemical structure.

In general, chlorinated hydrocarbons have a longer residual time than other chemicals. As a group, chlorinated hydrocarbons have a lower acute toxicity

to warm-blooded animals than organo phosphates and carbamates. They have been widely used in past years, but have been used less frequently in recent years. Their long residual nature, the fact that they are stored in fatty tissue, and the fact they undergo biological magnification in natural food chains are some of the reasons for using them less. Such chemicals as DDT, chlordane, aldrin, dieldrin, endrin, BHC, lindane, and toxaphene are examples of this group of insecticides.

Organo phosphates are generally much less persistent in the environment than chlorinated hydrocarbons. However, many of these are highly toxic to warm-blooded animals. Therefore, much care should be exercised in mixing and applying them. As a group, they are probably the most commonly used insecticides today. Some of these chemicals are systemic when used on crops. Some of the more commonly used organo phosphate insecticides are methyl parathion, parathion, malathion, disulfofon, phorate, diazinon, dimethoate, fensulfothion, azinphos methyl, and methidathion.

Carbamate insecticides are the newest group to gain general usage. Most of the more useful of this group are highly toxic to warm-blooded animals. Several of them are effective systemically. Most are not persistent in the environment. Some examples of the carbamate group are carbaryl, carbofuran, methomyl and aldicarb.

Disease Control Chemicals

Pesticides used to control plant diseases are classified as fungicides, bactericides, and nematicides.

Fungicides -- Fungicides are used to control diseases

caused by fungi. They are used as seed treatments and soil treatments, but by far, most of the fungicide usage is in foliage treatment. To be effective, most fungicides must be applied before a disease occurs. These are protectant fungicides.

There are a few eradicant fungicides. Some have both protectant and eradicant activity. A few systemic fungicides are now available.

Fungicides are classified as inorganic and organic.

Inorganic fungicides include sulfur, copper-sulfate, copper oxide and Bordeaux mixture. Generally, these fungicides are not as effective as the newer organic fungicides. The inorganic materials are often more phytotoxic than the organic materials. Although they are still used to some extent, they have largely been replaced by organic fungicides.

Common organic fungicides includes maneb, zineb, captan, benomyl, and chlorothalonil. These are fairly broad spectrum fungicides that will control many leaf diseases. A number of others, such as karathane, which is used exclusively to control powdery mildew, are used for specific diseases.

Fungicides as a group are not highly toxic to warm-blooded animals, nor do they persist in the environment for any length of time.

Bactericides -- Bactericides are pesticides used to control bacterial diseases. Certain inorganic copper fungicides serve as bactericides. Streptomycin is an anti-biotic bactericide. It is effective in the control of fireblight of apple and pear.

Nematicides -- Nematicides are applied to the soil to control nematode diseases.

Fumigant nematicides are usually liquids which are injected into the soil. After injection, they form gases. These gases move upward and outward to form a "U"-shaped fumigated area. Fumigant nematicides include DBCP, ethylene dibromide, dichloropropanes, methyl bromide and chloropicrin.

Non-fumigant nematicides sold as liquids or granules are applied to the soil surface or incorporated into the soil. Some may move downward with water movement. The non-fumigant nematicides include fensulfothion (Dasanit), ethoprop (Mocap), carbofuran (Furadan) and aldicarb (Temik).

Nematicides, particularly the non-fumigant type, are toxic to warm-blooded animals and should be handled with great care.

Weed Control Chemicals

Pesticides used to control higher plants are known as herbicides. Herbicides may be classified according to use.

Selective Herbicides -- Herbicides in this group kill some plants while having little or no effect on others. The selective nature of these herbicides permits their use to eliminate weeds with little or no adverse effect on crops. Selectivity is primarily based upon differences in physiology in plants much as differences in absorption and translocation of the chemical. Some examples are atrazine, 2,4-D, trifluralin, and alachlor.

Non-selective Herbicides -- These herbicides kill vege-

tation without regard to species. Representative examples are paraquat, prometryne, and bromacil.

Contact Herbicides -- kill or affect only the plant tissues which are covered in application. They produce plant tissue kill within a few hours to a few days after application. Certain of the contact herbicides may provide residual control as well as contact kill (linuron, diuron, etc.) while others provide little or no residual control (dinoseb, paraquat).

Contact herbicides may be applied as directed or semi-directed sprays to avoid or minimize contact with crop foliage. This permits removal of weeds with minimal crop injury.

Translocated Herbicides -- are absorbed by plant foliage and/or roots and are translocated throughout the plant. They generally require several days to several weeks to produce plant kill. Some examples are 2,4-D, 2,4-DB, and dalapon.

Root absorbed herbicides are generally most effective if applied before weed seed germination. Generally higher rates of these herbicides are required to control established weeds than is required for control of germinating weeds. These treatments are highly effective for control of annual weeds in cropland. Some representative examples are atrazine, cyanazine, and trifluralin.

Foliage absorbed herbicides are used for control of both annual weeds and established perennial weeds. Certain ones are highly effective treatments in the control of established perennial weeds. Examples: dalapon

for control of perennial grass; and 2,4-D, 2,4,5-T, etc. for control of perennial broadleaf weeds.

Special Problems

Pre-Harvest and Re-entry Intervals -- Many pesticides are restricted by a minimum time from last application to harvest. This time requirement is known as the pre-harvest interval. The label and Extension pest control publications furnish needed information on this restriction. Pre-harvest intervals should be carefully observed to prevent harvesting an illegally contaminated product.

The minimum time between applying a chemical and workers entering the treated area is known as the re-entry interval. This restriction is presently required for only certain pesticides that are highly toxic to warm-blooded animals. Re-entry intervals should be carefully observed.

Phytotoxicity -- When a chemical applied to a plant causes injury, the chemical is said to be phytotoxic (plant toxic). If the plant is a weed and the chemical is a herbicide, the result is desired, but usually the word "phytotoxic" is used when a pesticide adversely affects plants. Phytotoxicity may occur due to drift onto non-target plants, using excessive rates, mixing of chemicals that are not toxic when used alone, and using chemicals in a more concentrated form than recommended. Certain weather patterns may cause or increase the amount of phytotoxicity. For example, exceptionally bright, hot, dry weather following a period of cooler weather usually increases plant toxicity (injury), or, get some phytotoxicity even when using pesticides in accordance with recommended practices. But a severe

phytotoxicity problem is not unusual and usually occurs when pesticides have been improperly applied.

To avoid phytotoxicity, apply chemicals within recommended rates. Do not mix chemicals unless the label indicates it is all right. Time applications according to recommendations. Use recommended water rates.

Residues -- The amount of a pesticide that remains after application is the residue. The ideal pesticide would be one that is residual enough to give control of a pest for the length of time needed and then break down into completely harmless chemicals. Unfortunately, most pesticides are not "ideal". The long residual nature of chlorinated hydrocarbons is one of the main reasons they are being used less frequently. Usually a tolerance is set for each chemical that is registered on a crop. It is expressed in parts per million (ppm). The residue that remains on the harvested crop cannot exceed the tolerance that was set when the pesticide was labeled. This has a direct relationship to the pre-harvest interval. Registered and recommended rates should not be exceeded because the residue may exceed the legal tolerance.

The residue of pesticides in soils may create problems. If a chemical is legally used on one crop, and it is not legal on the succeeding crop, an illegal residue could result.

Environmental Contamination -- Chlorinated hydrocarbon insecticides have a long residual effect. They are the most likely chemicals to cause contamination of the environment for an extended period. These chemicals should be used in strict accordance with recommendations. If possible, avoid using a broadcast treatment over a very large area, such as an entire county or several

counties. Before undertaking large-scale control efforts, consult governmental agencies about recommendations, precautions and restrictions.

Non-target Injury -- Care should be exercised not to contaminate non-target areas when applying a pesticide. This is particularly true of food and feed crops, bodies of water, apiaries, woodlands, and urban areas. Information on the least hazardous recommended chemical to use, where there is danger of contamination, can be obtained from County Extension Offices.

Drift is probably the chief culprit contributing to contamination of non-target areas. Pesticides should be applied when there is little or no wind. Pesticides should not be applied if wind exceeds 10 miles per hour. Using extremely low volume and air delivery spraying systems increases the problems of drift. Some pesticides, particularly herbicides, may badly damage or completely destroy some crops if they are allowed to drift onto them. The phenoxy herbicides (2,4-D, 2,4,5-T, etc.) are examples of the type chemicals that can be very damaging.

Such precautions as spraying when there is little or no wind, using the least volatile forms of dangerous chemicals, and avoiding breaking the spray into really fine particles will help prevent these problems.

Contamination of Soil and Water -- When pesticides are being used, care should be taken to prevent undue contamination

of the soil and bodies of water. Select the pesticide that is least likely to contaminate. For example, carefully mark each swath in order to avoid a double application. Some herbicides and long residual insecticides may have a carry-over effect if excessive rates are used. This could contaminate or destroy subsequent crops.

When bodies of water are near to the area being treated, select the recommended chemical that would be least likely to cause contamination. Apply the chemical when there is no wind, or when the wind would blow the chemical away from the water. Do not apply the chemical when heavy washing rain is probable.

Additional References

Insect Pests

University of Missouri Science and Technology Guides	
Corn Soil Insect Control	4150
Cotton Insect Control Recommendations	4252
Controlling the Alfalfa Weavil	4560
Controlling Insect Pests in Home Gardens	6206
Insects in Farm Stored Grain, Their Prevention and Control	7100
Missouri Insect Control Recommendations Handbook - Current Edition	

Disease Pests

University of Missouri Science and Technology Guides	
Corn Stalk Rots in Missouri	4152
Corn Stunting Virus Diseases in Missouri	4153
Cotton Disease Symptoms and Control Methods	4256
The Soybean Cyst Nematode	4450
Southern Corn Leaf Blight	4154
Fireblight	6020
Crown Gall Disease of Nursery Stock	6880
1975 Home Fruit Spray Schedules	6010

Commercial Spray Schedule - Univ. of Mo. 1975

Grape	M.P. 263
Apple	M.P. 264
Peach	M.P. 265
Strawberry	M.P. 266

Weed Pests

University of Missouri Science and Technology Guides	
Recommendations for Weed Control in Corn	4136
Recommendations for Weed Control in Cotton	4236
Chemical Weed Control Recommendations for Small Grains	4346
Recommendations for Weed Control in Sorghum	4348
Chemical Weed Control Recommendations for Soybeans	4436
Chemical Weed Control Recommendations for Legumes and Pasture	4546

Issued in furtherance of cooperative extension work, acts of May 8 and June 30, 1914, in cooperation with the United States Department of Agriculture. Carl N. Scheneman, Vice President for Extension, Cooperative Extension Service, University of Missouri, Columbia, Mo. 65201. The University of Missouri is an equal employment and educational opportunity institution.